MOUNTAIN RUN PCB STUDY

B75-020

JOSEPH A. RYDER JR.

JAMES R. MCNEAL

DIVISION OF ECOLOGICAL STUDIES

BUREAU OF SURVEILLANCE AND FIELD STUDIES

STATE WATER CONTROL BOARD

JUNE 1977

ABSTRACT

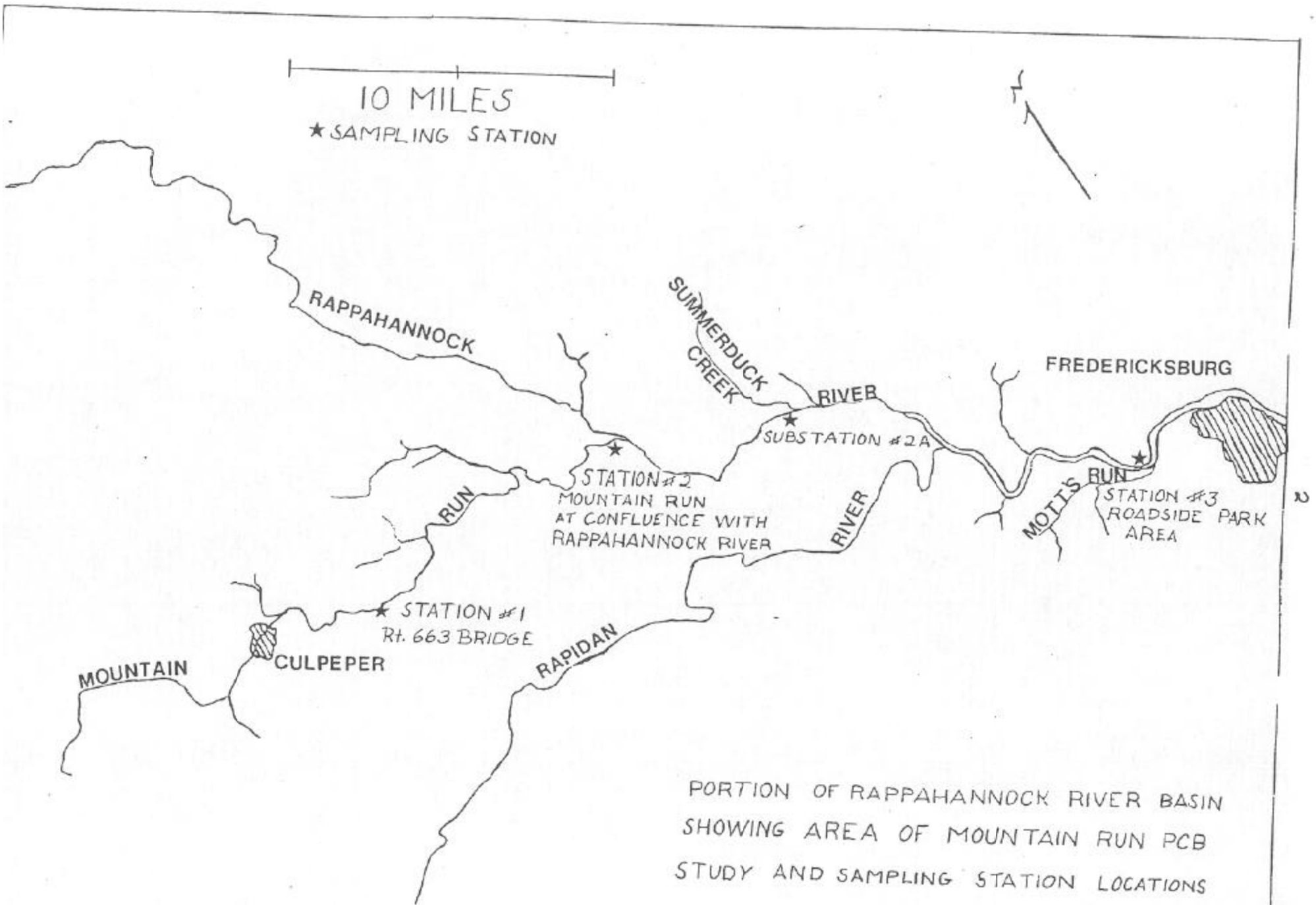
Following identification of the Culpeper Sewage Treatment Plant (STP) as a source of PCB contamination, the Virginia State Water Control Board (SWCB) undertook a study of the Mountain Run drainage to determine existing levels of PCBs in sediment, water and fish. The initial study uncovered a serious problem, with a majority of the fish sampled exceeding the Food and Drug Administration (FDA) 5.0 ppm action level for the edible portion of fish. This study was initiated late in 1971 by Joseph G. Wallmeyer. The results of his study prompted a second study in July of 1975. Results of the second survey indicate that PCB residues were found to have decreased substantially.

INTRODUCTION

Recently a family of compounds known as Polychlorinated Biphenyls (PCBs) have come to the attention of environmentalists as another persistent chlorinated hydrocarbon. Routine pesticide monitoring showed high levels of PCBs being discharged from an STP located on Mountain Run.

Mountain Run is a stream with its headwaters near the Bruce Mountain area of Culpeper County. It flows west to east through the Piedmont Province of Virginia to a confluence with the Rappahannock River about 25 miles west of Fredericksburg (Figure 1). Mountain Run flows through an area of rich farmland and little industrialization.

Culpeper is the main community along Mountain Run and the STP located there was found to be discharging PCBs. This discharge of PCBs was pinpointed during a study conducted by Wallmeyer in 1971. Water samples were collected from the sewer lines leading into the plant. Line 5 was found to be contaminated with PCBs, and samples were collected from the only upstream discharge, a uniform rental operation. The effluent contained 350 ppb of Aroclor 1254, while a piece of cloth (from a new uniform) contained 0.3 ppm of Aroclor 1248.



PORTION OF RAPPAHANNOCK RIVER BASIN SHOWING AREA OF MOUNTAIN RUN PCB STUDY AND SAMPLING STATION LOCATIONS

FIGURE 1

These results prompted Wallmeyer to collect fish and mud samples in the winter of 1971.

In July of 1975 several species of fish were taken at the same stations where Wallmeyer had sampled in the original survey. Fish samples were taken again at a point located about 3 to 5 miles downstream of the Culpeper STP. Station 2 was again sampled in 1975 at the confluence of Mountain Run with the Rappahannock River but because of poor fishing conditions the 1975 survey team chose an additional downstream substation. This substation is located approximately 3 miles downstream from station 2, at the confluence of Summer Duck Creek with the Rappahannock River (Figure 1). The third station sampled by Wallmeyer in 1971 and again in July of 1975 is located at the confluence of Motts Run with the Rappahannock River with access via a roadside park area. Control fish were taken from Mountain Run Lake, a Game Commission lake located a couple miles east of Culpeper.

PCBs

Polychlorinated Biphenyls were produced only by Monsanto Company in this country. Monsanto produced PCBs under the trade name of Aroclor with a four number suffix such as Aroclor 1254. The 12 designates that the compound is a pure biphenyl (as opposed to a terphenyl or blend of biphenyls and terphenyls) and the two digit numeral following the 12 designates the weight percent chlorine (Pekall and Lincer, 1970).

PCBs have a high chemical stability and a low solubility in water. They also have good fireproofing characteristics, and serve quite well as dielectrics.

Three properties make the use of PCBs essential for hydraulic transformers, and insulating condensers (Shannon, Ludwig, Valdmanis, 1973). Other industrial applications of PCBs include hydraulic lubricants, plasticizers, printing inks, and various types of surface coatings.

L.L. Frederick (1975) in his study concerning comparative uptake of PCBs and Dieldrin by the white sucker (*Catostomus commersoni*) found that the accumulation of Aroclor 1232 is generally similar to chlorinated hydrocarbon insecticides. PCBs, like the chlorinated hydrocarbon insecticides, are subject to biological magnification by marine vertebrates. Stalling (1971) working with bluegill (*Lepomis macrochirus*) showed concentration factors ranging from 26,500 to 52,000 in an eleven week test exposure to Aroclor 1248 and 1254 in water containing from 6 to 14 ppb. Spot (*Leiostomus xanthurus*) and pinfish (*Lagondon rhomboides*) died when exposed for 14-15 days to 5 ppb of Aroclor 1254 (Hansen, Parrish, Lowe, Wilson, and Wilson, 1971).

Nimmo, Blackman, Wilson, and Forester (1971) once again demonstrated the toxicity of PCBs by killing pink shrimp (*Penaeous duorarum*) with a 15 day exposure to 0.94 ppb of Aroclor 1254.

Fish seem to have a mechanism for ridding themselves of the PCBs. Hansen et. al. (1971) show Aroclor 1254 was slowly lost from the tissue of spot after they were placed in PCB-free flowing water. After 84 days of flushing, the relative residuals in whole fish dropped 73%.

Much work has been done in the last five years on the biodegradation of PCBs. In particular the 1254 and 1260 Aroclors, are degraded very little, if at all during secondary wastewater treatment. Removal is largely by physical separation with the primary sludges and accumulation in the activated sludge (Frederick, 1975). Some progress is being made with the biodegradation aspects, Ahmet and Focht (1973) described the degradation of PCBs by two species of the *Achromobacter* bacteria.

As with DDT, the Food and Drug Administration (FDA) has set a a 5.0 ppm guideline on PCB in edible tissue of fish. Recently there has been a proposal within the FDA to drop the PCB tolerance level in fish to 2.0 ppm but no further action has been taken at this time.

METHODOLOGY

Fish were taken by hook-and-line and electrofishing. The fish were wrapped in aluminum foil and shipped to Consolidated Laboratories in Richmond. The fish were cleaned in manner similar to the preparation necessary for pan-frying (head, scales, fins, and visceral material were removed). The samples, therefore consisted of edible meat. Each fish was macerated in a commercial meat grinder (Hobart) prior to solvent extraction. Gas chromatography as well as mass spectrometry were used to obtain the PCB residues.

No sediment samples were taken by the Division of Ecological Studies on the second survey. Northern Regional Office did take sediment samples at this time, and this data is incorporated into this paper.

RESULTS

Control

Only sunfish were taken at the control (Mountain Run Lake). Eleven samples were taken. No trace of PCBs was found in these samples (Table 1).

Station 1

With the exception of one black crappie (*Poxomis nigromaculatus*), bluegill (*Lepomis macrochirus*) and pumpkinseed (*Lepomis gibbosus*) were the only species of fish taken at the first station (Table 2). The average PCB residue in pumpkinseed was 0.266 ppm, while bluegill showed non-detectable levels (Figure 2). Fish sampled at this station yielded residues of Aroclor 1254 only.

Sediment samples taken in June of 1975 below the STP at Station 1 yielded PCB levels of 0.7 ppm in the top inch, 0.8 ppm in the second inch, and 0.4 ppm in the third inch.

Station 2

Bluegill and redbreast sunfish (*Lepomis auritus*) were taken at Station 2 in the second survey. The bluegill showed no detectable level of PCBs, and

Table 1. Fish Tissue Samples, Mountain Run Lake (Control - July 1975).

Fish	Weight gm.	Length inches/cm	Sex	Type	PCB Value ppm
Pumpkinseed	50.7	5.5/14.0	M		ND
	44.5	5.5/14.0	M		ND
	39.0	5.0/12.7	M		ND
	39.8	5.0/12.7	F		ND
	31.4	4.5/11.4	Imm		ND
Bluegill	59.0	6.0/15.2	M		ND
	51.0	5.5/14.0	F		ND
	48.0	6.0/15.2	F		ND
	31.0	4.5/11.4	M		ND
	30.4	4.5/11.4	F		ND
	25.9	4.5/11.4	M		ND

Table 2. Fish Tissue Samples, Mountain Run at Rt. 663 bridge (Station 1 - July 1975).

Fish	Weight gm	Length inches/cm	Sex	Type	PCB Value ppm
Pumpkinseed	59.5	5.5/14.0	M	Aroclor 1254	0.1
	22.0	3.5/8.9	Imm	Aroclor 1254	0.5
				Heptachlor Epoxide	0.01
	14.5	2.5/6.3	M	Aroclor 1254	0.2
Bluegill	134.0	7.0/17.8	F		ND
	89.0	6.0/15.2	F		ND
black crappie	52.5	6.0/15.2	M	Aroclor 1254	0.1

the redbreast sunfish yielded average values of 0.13 ppm (Tables 3 and 4). None of the fish taken from the July of 1975 survey approached FDA's 5.0 ppm action level, and 60% of the fish sampled showed no detectable residues of PCBs.

Fish sampled at this station showed no trace of Aroclor 1242, only Aroclor 1254 and traces of the pesticides DDE, DDT, and TDE were found.

Station 3

Only 4 out of 25 fish (16%) showed any trace of PCBs at the third station (Table 5). Thirty-three percent of the redbreast sunfish were contaminated with PCBs, but the three values obtained were narrowly over the limits of detection.

One bluegill out of seven showed residues of PCBs. The PCBs in this fish were in the form of Aroclor 1242.

Other species sampled that yielded non-detectable levels include black crappie, rock bass (*Ambloplites rupestris*), smallmouth bass (*Micropterus dolomieu*), and white suckers.

DISCUSSION

While there is insufficient data to undertake a complete statistical analysis it can be seen by direct comparison of the 1971 and 1975 data that the fish have eliminated most of the PCBs found in the earlier studies (Tables 6, 7, 8). Station one yields the best evidence for the purging of the PCBs. Nearly the same number of sunfish were taken on both surveys. The fish taken in 1975 show less than 1% of the contamination found in 1971 (Figure 2). Sediments taken below the STP would tend to verify this loss of PCBs in fish. Sediments taken by Northern Regional Office were 6.4% of the 1971 values (Figure 3). The culmination of this data yields further proof to the theory of Hansen, Lowe, Wilson, and Wilson (1971) that fish contaminated with Aroclor 1254, when flushed with clean water, tend to rid themselves of residues of PCBs.

Table 3. Fish Tissue Samples, Mountain Run at Confluence with the Rappahannock River (Station 2 - July 1975).

Fish	Weight gm	Length inches/cm	Sex	Type	PCB Value ppm
Bluegill	86.0	6.0/15.2	F		ND
	56.0	5.5/14.0	M		ND
	46.0	5.0/12.7	F	DDE	0.03
Redbreast sunfish	165.5	8.0/20.3	F	Aroclor 1254	0.6
				DDT	0.1
				TDE	0.1
	136.0	7.5/19.0	F		ND
	133.5	7.5/19.0	M	Aroclor 1254	0.3
	100.9	7.0/17.8	F		ND
	91.9	6.5/16.5	M	Aroclor 1254	0.1
				TDE	0.02
	90.0	6.0/15.2	F	Aroclor 1254	0.3
				DDT	0.04
				DDE	0.02
	83.5	6.5/16.5	M		0.2
	73.0	5.5/14.0	M		ND
	33.0	4.5/11.4	M		ND

Table 4. Fish Tissue Samples, Rappahannock River at Summer Duck Creek (Station 2A - July 1975).

Fish	Weight gm	Length inches/cm	Sex	Type	PCB Value ppm
Bluegill	49.0	5.0/12.7	F		ND
	48.2	5.5/14.0	F		ND
Redbreast sunfish	142.0	7.0/17.8	F		ND
	129.5	7.0/17.8	M	DDE	0.01
Smallmouth bass	118.0	8.5/21.6	F	DDE	0.01

Table 5. Fish Tissue Samples, Rappahannock River at Motts Run (Station 3 - July 1975).

Fish	Weight gm	Length inches/cm	Sex	Type	PCB Value ppm
Pumpkinseed	44.7	5.0/12.7	M		ND
bluegill	172.5	7.5/19.0	M		
	44.0	5.0/12.7	F		ND
	34.2	5.0/12.7	M	Aroclor 1242	ND
	32.0	4.5/11.4	M		0.02
	28.5	5.0/12.7	M		ND
	27.4	4.5/11.4	F		ND
	25.0	4.3/10.9	M		ND
					ND
Redbreast sunfish	126.6	7.5/19.0	M	Aroclor 1254	0.02
	102.0	7.0/17.8	M		ND
	86.0	7.0/17.8	F		ND
	62.0	5.5/14.0	M	Aroclor 1254	0.04
	51.8	5.5/14.0	M		ND
	39.0	5.0/12.7	M		ND
	36.0	5.0/12.7	F		ND
	33.0	4.5/11.4	M		ND
	32.0	4.5/11.4	F		0.02
Smallmouth bass	111.5	8.0/20.3	F		ND
	29.2	5.5/14.0	M		ND
Rock bass	171.5	8.0/20.3	F		
	80.5	6.0/15.2	M		ND
	68.0	6.0/15.2	M		ND
	63.2	6.0/15.2	M		ND
					ND
Black crappie	112.3	7.5/19.0	M		ND
White sucker	81.0	7.0/17.8	M		ND

Table 6. Fish Tissue Samples, Mountain Run at Rt. 663 bridge (Station 1, October 1971).

Fish	Aroclor 1242	Aroclor 1254	Total	Other
Pumpkinseed	-	28.0 ppm	28.0	-
Pumpkinseed	-	22.0	22.0	-
Pumpkinseed	-	11.0	11.0	-
Bluegill	-	11.5	11.5	-
Bluegill	-	56.0	56.0	-
Bluegill	-	4.3	4.3	-

Table 7. Fish Tissue Samples, Mountain Run at Confluence with the Rappahannock River (Station 2, January 1972).

Fish	Aroclor 1242 ppm	Aroclor 1254 ppm	Total ppm	Other
White sucker	0.10	0.46	0.56	-
	0.08	0.89	0.97	-
	0.20	0.31	0.51	-
	0.25	1.80	2.05	-
	0.14	0.61	0.75	-
Redhorse sucker	0.29	4.30	4.59	-
	-	0.84	0.84	-
	-	7.00	7.00	-
	-	0.36	0.36	-
	-	4.70	4.70	-
Redbreast sunfish	-	4.60	4.60	-
Smallmouth bass	0.38	47.00	47.28	-

Table 8. Fish Tissue Samples, Rappahannock River at Roadside Park Area (Station 3, January 1972).

Fish	Aroclor 1242 ppm	Aroclor 1254 ppm	Total ppm	Other
Bluegill	0.11	1.10	1.21	-
	-	0.50	0.50	-
	0.32	0.06	0.38	-
	-	2.50	2.50	-
	0.05	0.67	0.72	-
	-	0.87	0.85	-
Black crappie	-	6.00	6.00	-
	-	-	ND	-
	-	3.40	3.40	-
	-	0.13	0.13	-
	0.02	0.20	0.22	-
Redhorse sucker	0.08	0.30	0.38	-
	0.17	0.10	0.27	-
	-	1.10	1.10	-
	0.13	0.89	1.02	-
	0.18	0.64	0.82	-
Largemouth bass	-	0.15	0.15	-
	-	0.40	0.40	-

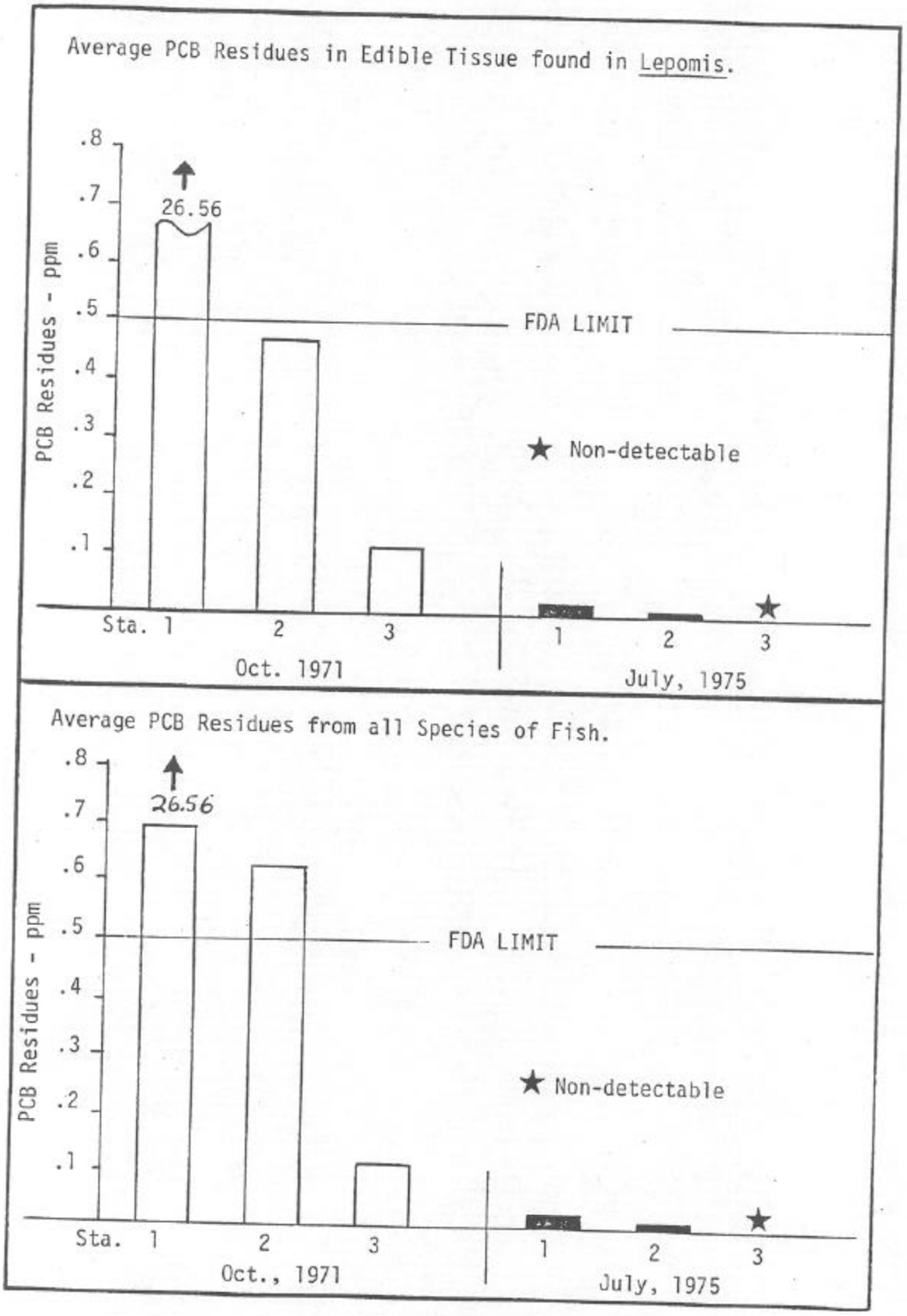

Average PCB Residues in Edible Tissue found in Lepomis.
PCB Residues - ppm
.8
.7
.6
.5
.4
.3
.2
.1
26.56
FDA LIMIT
★ Non-detectable
Sta. 1
2
3
1
2
3
Oct. 1971
July, 1975
Average PCB Residues from all Species of Fish.
PCB Residues - ppm
.8
.7
.6
.5
.4
.3
.2
.1
26.56
FDA LIMIT
★ Non-detectable
Sta. 1
2
3
1
2
3
Oct., 1971
July, 1975

Figure 2.

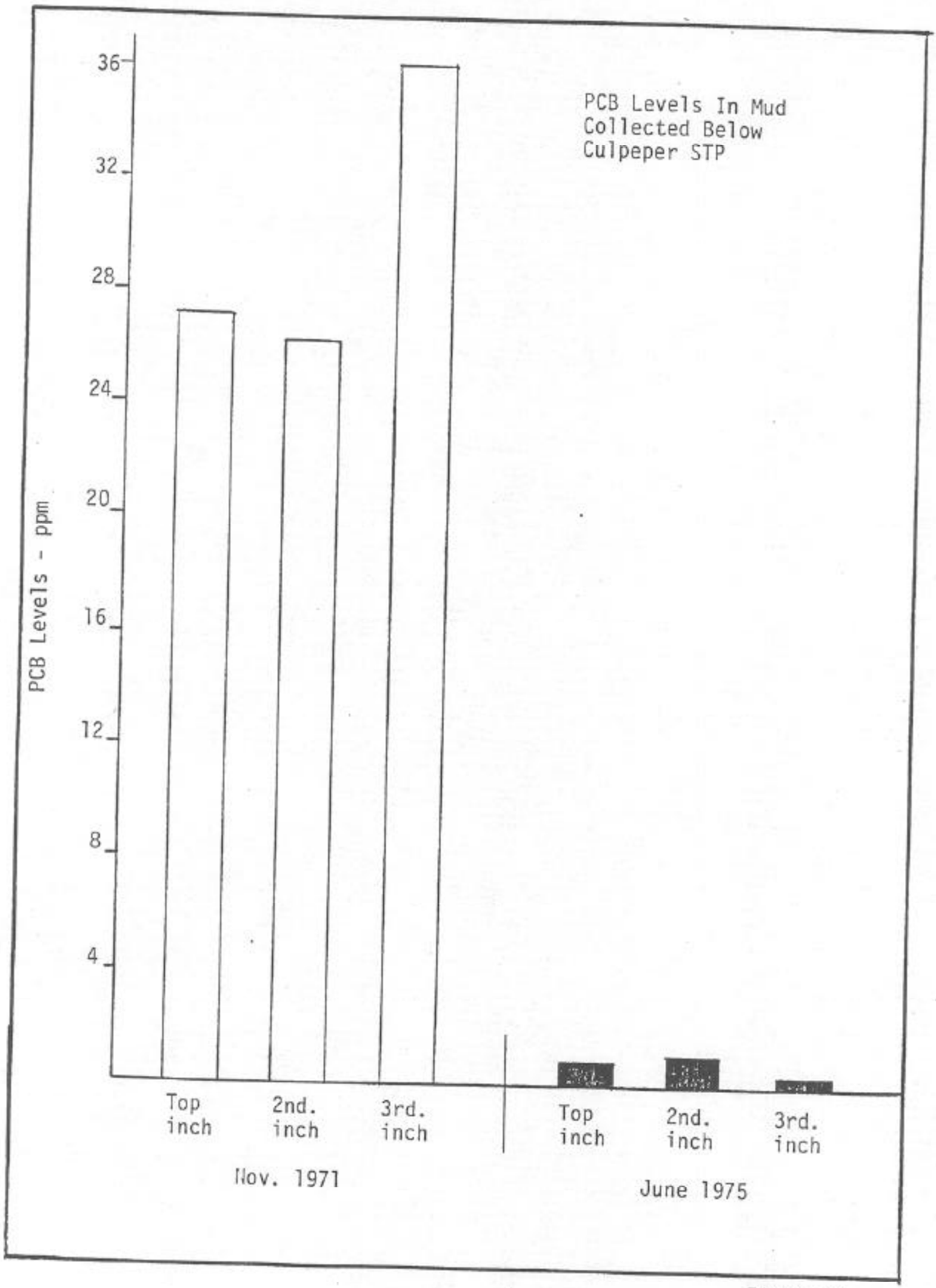

PCB Levels In Mud
Collected Below
Culpeper STP
PCB Levels - ppm
36
32
28
24
20
16
12
8
4
Top inch
2nd. inch
3rd. inch
Nov. 1971
Top inch
2nd. inch
3rd. inch
June 1975

Figure 3.

Sunfish from Stations 2 and 3 show the same reduction of PCB residues. The remainder of the fish taken at these stations also show these tendencies; however, it is hard to make direct comparisons because of the different species collected for each study.

If one were to make a comparison between the fish sampled in 1971 and 1975 at station three, probably the best comparison could be made between the crappie and the rock bass. Both the crappie and the rock bass have similar feeding habits and they both occupy nearly equal links in the food chain (Dave Chance, SWCB Biologist via personal communication). Five crappie taken in 1971 showed average residues of 1.95 ppm. Four rock bass and one crappie taken from the same station in 1975 yielded no detectable trace of PCBs.

Considerable doubt has emerged as to the origin of the PCBs. Wallmeyer (1971) traced the contaminants to the discharge of the Uniform Rentals Company. Recent (8 April 1975) water samples taken by Northern Regional Office at Uniform Rentals discharge have yielded non-detectable values. Two other industries on the same sewage line have emerged as possible contaminants. They are the Rochester Corporation, and Old Dominion Manufacturing Company.

It should be noted that Uniform Rentals burned down in November of 1974, and remained closed until April of 1975. Their source of PCBs may have been eliminated in some manner, as a result of the fire.

Although there has been a drastic reduction in the PCB levels in fish during the last four years it is recommended that the upper Rappahannock and its tributary, Mountain Run, be the subject of regular monitoring of fish, water, and sediments. This monitoring should be continued since little is known concerning the relationship between residues of PCBs in mud, and residues of PCBs in fish. The monitoring should also be continued as long as the source of the PCB contamination remains a mystery.

REFERENCES

Ahumet, M. and D.D. Focht. 1973. Can. J. Microbiol, 19, 47-52.

Frederick, L.L. 1975. Comparative uptake of a Polychlorinated Biphenyl and Dieldrin by the White Sucker (*Catostomus commersoni*). J. Fish Res. Board Can. 32:1705-1709.

Hansen, D.J. and P.R. Parrish. 1971. Chronic Toxicity, Uptake, and Retention of Aroclor 1254 in Two Estuarine Fishes, U.S. Environmental Protection Agency, Gulf Breeze Laboratory Sabine Island, Gulf Breeze, Florida.

Nimmo, D.R., R.R. Blackburn, A. Wilson Jr., J. Forester. 1971. Toxicity and distribution of Aroclor 1254 in the pink shrimp. (Environmental Protection Agency, Gulf Breeze Laboratory, Sabine Island, Gulf Breeze, Florida). Mar. Biol. 11(3) 191-197.

Peakall, D.B. and J.L. Lincer. 1970. Polychlorinated Biphenyls - Another Long Life Widespread Chemical in the Environment. Biosci. 20:958-964.

Shannon, E.E., F.J. Ludwig, and I. Valdmanis. 1973. PCBs in Municipal Wastewaters. Wastewater Technology Centre, Environmental Protection Service, Environment, Canada

Stallings, D.L. 1971. PCB Newsletter, U.S. Environmental Protection Agency. National Water Quality Lab., Duluth, Minn. 28 July: 13.

Wallmeyer, J.G. 1972. Mountain Run PCB Study. Va. State Water Control Board, Richmond, Va.